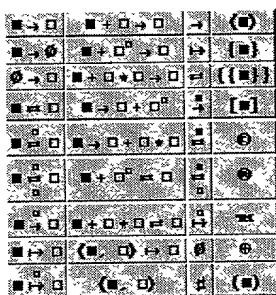




Jet Propulsion Laboratory
California Institute of Technology
300 Oak Grove Dr., Pasadena, CA 91109
©2000-2001, Patent Pending

▼ Reactions



▼ Cascades



► Functions

► Hill Function Options

▷ GRN Options

▷ NHCA Options

▷ **run Options**

► **About Cellerator™**



► **Jet Propulsion Laboratory**
California Institute of Technology

FIG. 1

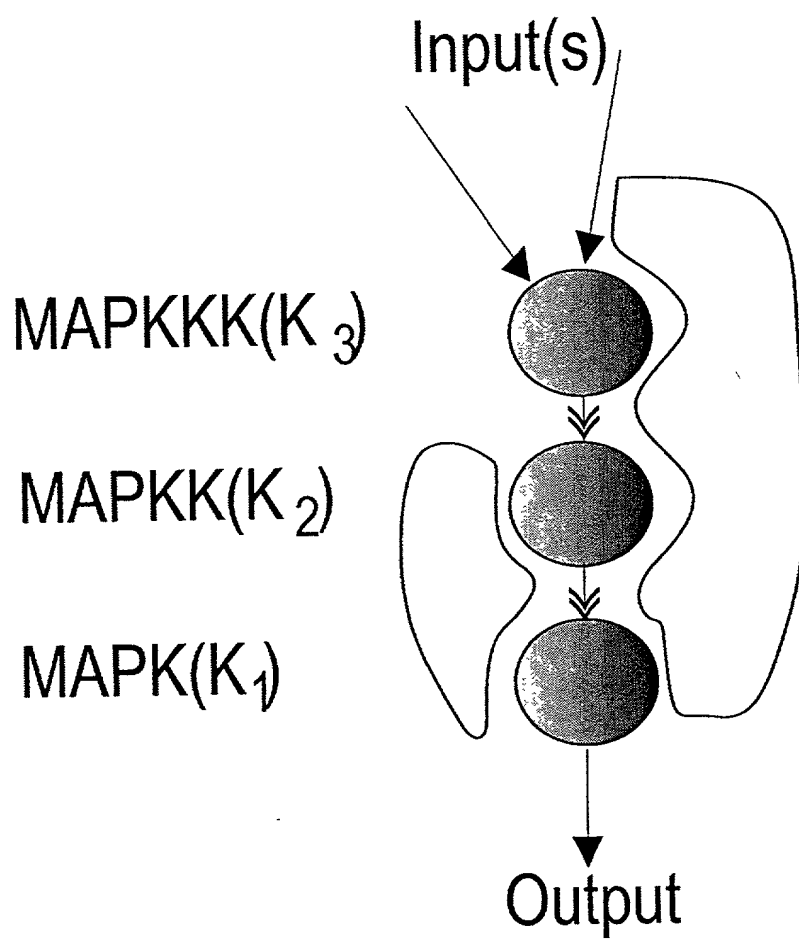


FIG. 2

```

      PFKA
r = {[ATP ⇌ ADP, k1, km1, k2],
     { ∅ → ATP, v1 },
     { ADP → ∅, v2 },
     { PFK + ADP2 ⇌ PFKA, k3, km3 } } ;
interpret[r]

```

```

{ [ADP'[t] == -v2 ADP[t] + k2 ATP_PFKA[t] -
  k3 ADP[t]2 PFK[t] + km3 PFKA[t],
  ATP'[t] == v1 + km1 ATP_PFKA[t] -
  k1 ATP[t] PFKA[t],
  ATP_PFKA'[t] == -k2 ATP_PFKA[t] -
  km1 ATP_PFKA[t] + k1 ATP[t] PFKA[t],
  PFK'[t] == -k3 ADP[t]2 PFK[t] + km3 PFKA[t],
  PFKA'[t] == k2 ATP_PFKA[t] +
  km1 ATP_PFKA[t] + k3 ADP[t]2 PFK[t] -
  km3 PFKA[t] - k1 ATP[t] PFKA[t] ],
  {ADP, ATP, ATP_PFKA, PFK, PFKA} }

```

FIG. 3

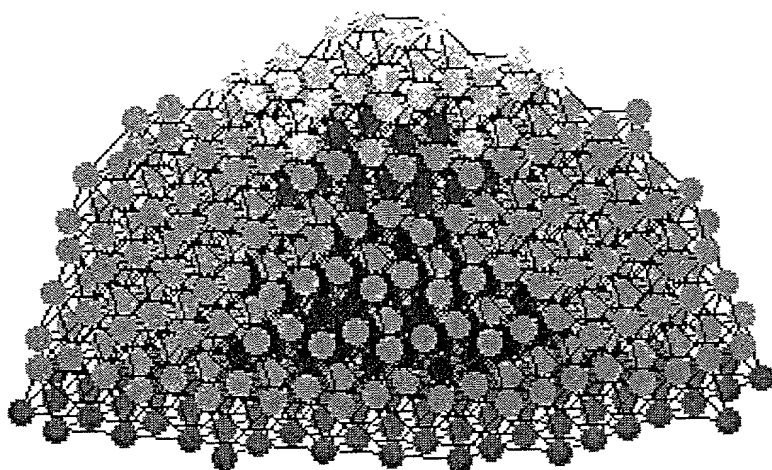


FIG. 4

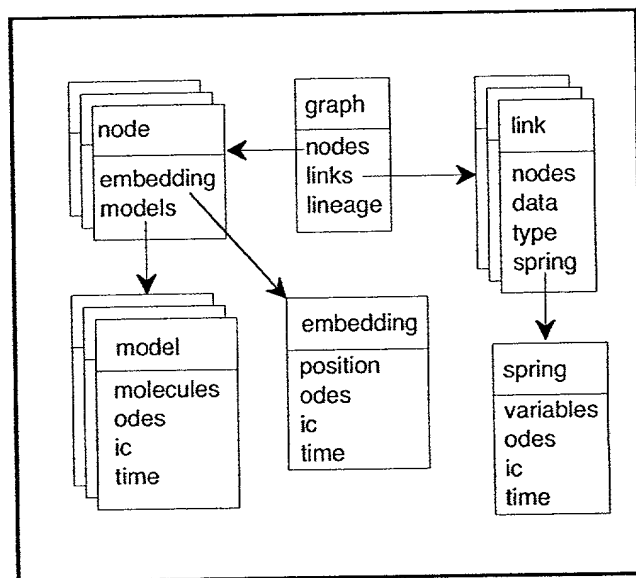


FIG. 5

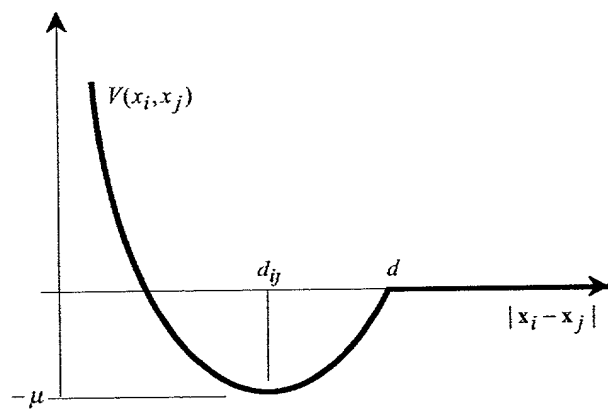


FIG. 6

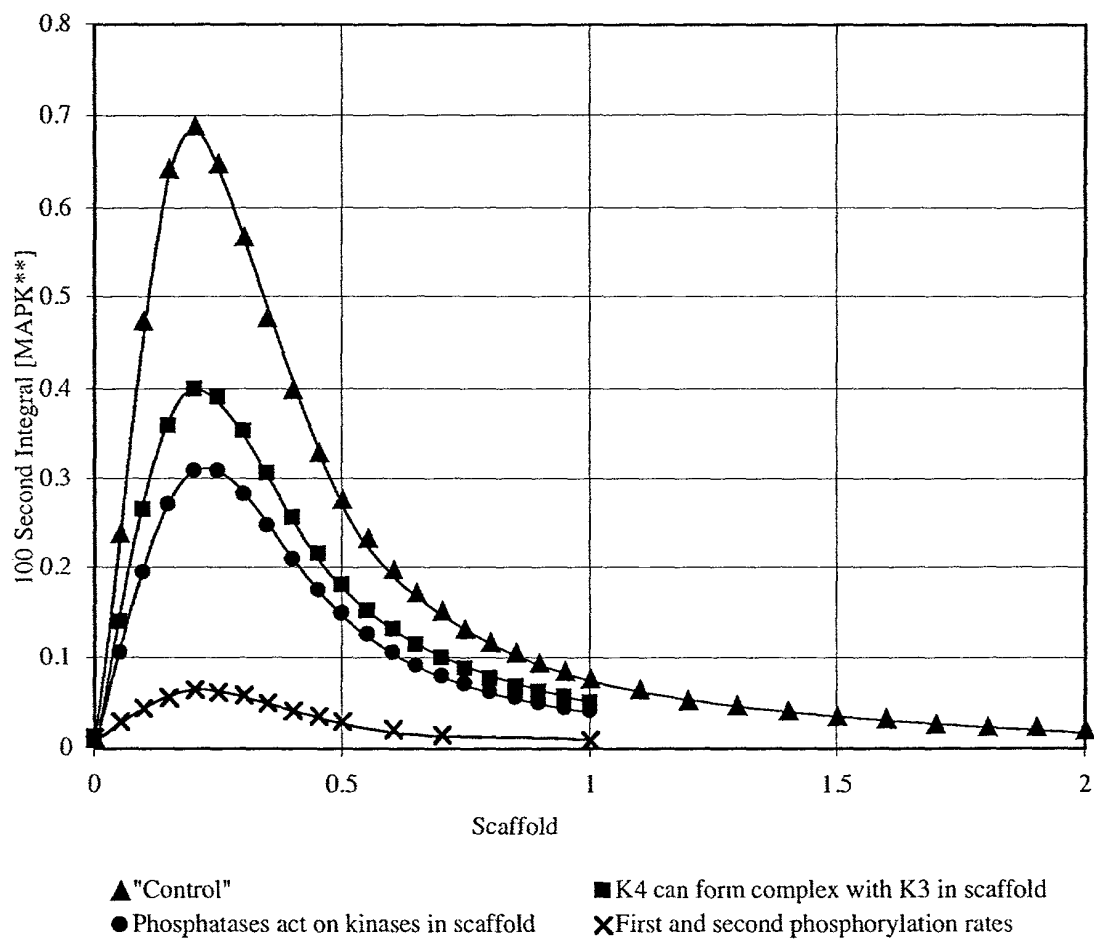


FIG. 7


```
g = unitGraph[odetype → local, threshold → 0.65,
returnPointer → False];
TraditionalForm[g]
```

```
graphDomain[nodes → {nodeDomain[embedding →
embeddingDomain(position → {x(1), y(1), z(1)}, odes → {x(1)'(t) == 0, y(1)'(t) == 0, z(1)'(t) == 0},
ic → {x(1)(0) == 0.114318, y(1)(0) == 0.864451, z(1)(0) == 0.235455}, time → 0)}],
models → {modelDomain[molecules → {c1, M(1), X(1)}, odes →
{c1'(t) == - 0.25 X(1)(t) c1[t] - 0.01 c1[t] + 0.025, M(1)'(t) == - 3 c1[t] (1 - M(1)(t))
- 1.5 M(1)(t) - 0.5 X(1)(t)}, X(1)'(t) == - 0.5 X(1)(t)},
ic → {c1[0] == 0.282391, M(1)(0) == 0, X(1)(0) == 0}, time → 0}, modelDomain[molecules →
{splv(1), tspl(1)}, odes → {splv(1)'(t) == θ(M(1)(t) - 0.65), tspl(1)'(t) == θ(splv(1)(t) - 1 × 10-6)},
ic → {splv(1)(0) == 0, tspl(1)(0) == 0}, time → 0}, modelDomain[molecules → {mass(1)},
odes → {mass(1)'(t) == mu mass(1)(t)}, ic → {mass(1)(0) == 1}, time → 0}]]
nodeData → {birth → 0}, nodeType → Cell, links → {}, lineage → tree(1)}
```

FIG. 9

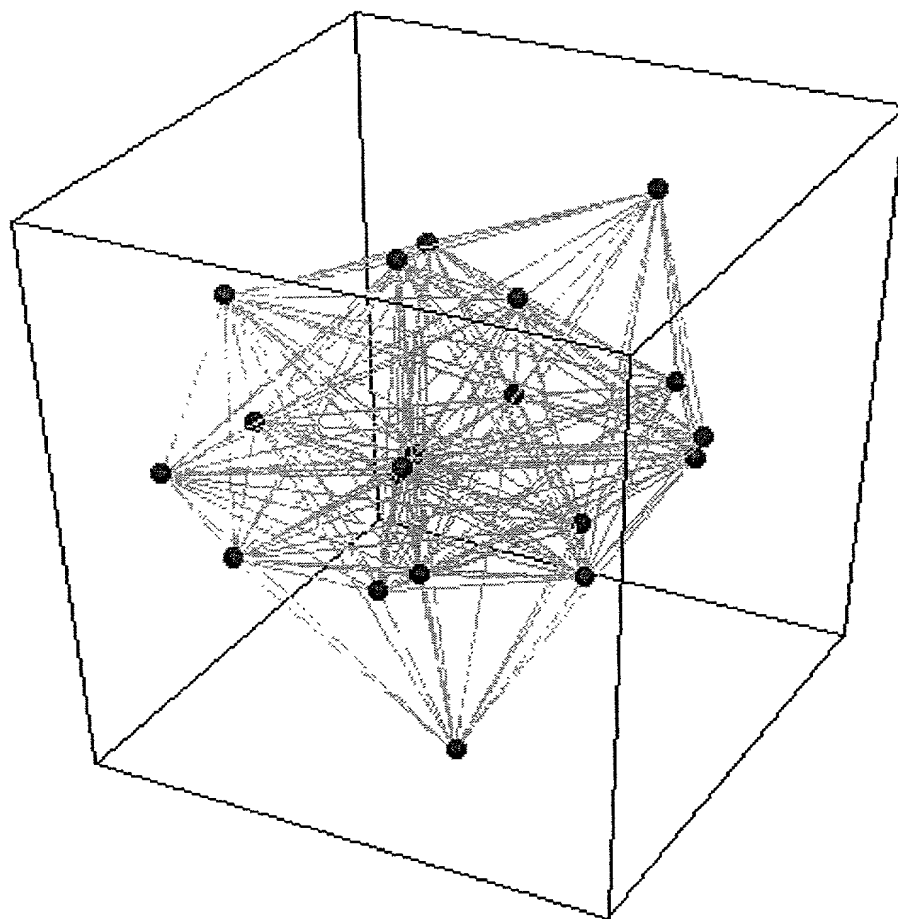


FIG. 10

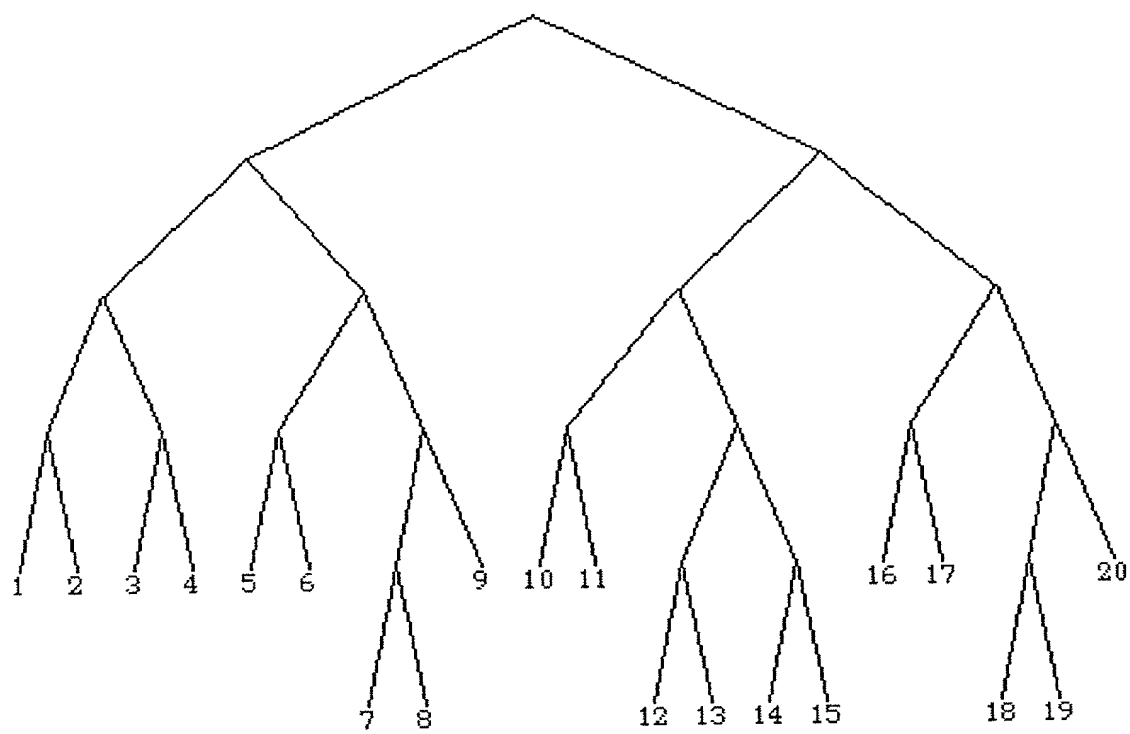


FIG. 11

phosphorylationReactions = gensScafPhosReacts[S, {2, 2, 1, 1}, K, kphase]

{S[0, 2, -1] → S[1, 2, -1], S[0, 2, 0] → S[1, 2, 0], S[0, 2, 1] → S[1, 2, 1], S[1, 2, -1] → S[2, 2, -1],
S[1, 2, 0] → S[2, 2, 0], S[1, 2, 1] → S[2, 2, 1], S[-1, 0, 1] → S[-1, 1, 1], S[-1, 1, 1] → S[-1, 2, 1],
S[0, 0, 1] → S[0, 1, 1], S[0, 1, 1] → S[0, 2, 1], S[1, 0, 1] → S[1, 1, 1], S[1, 1, 1] → S[1, 2, 1],
S[2, 0, 1] → S[2, 1, 1], S[2, 1, 1] → S[2, 2, 1], S[-1, -1, 0] → S[-1, -1, 1],
S[-1, 0, 0] → S[-1, 0, 1], S[-1, 1, 0] → S[-1, 1, 1], S[-1, 2, 0] → S[-1, 2, 1],
S[0, -1, 0] → S[0, -1, 1], S[0, 0, 0] → S[0, 0, 1], S[0, 1, 0] → S[0, 1, 1], S[0, 2, 0] → S[0, 2, 1],
S[1, -1, 0] → S[1, -1, 1], S[1, 0, 0] → S[1, 0, 1], S[1, 1, 0] → S[1, 1, 1], S[1, 2, 0] → S[1, 2, 1],
S[2, -1, 0] → S[2, -1, 1], S[2, 0, 0] → S[2, 0, 1], S[2, 1, 0] → S[2, 1, 1], S[2, 2, 0] → S[2, 2, 1]}

FIG. 14

Receive initial condition values, process parameters, and a user representation of the biological network, wherein the user representation is input using one or more of a series of biological network canonical input forms, wherein each canonical input form is based on a type of biological process in the biological network.

10



Generate a series of mathematical equations in an equation output canonical form based on the input representation of the biological network and the process parameters.

20



Numerically solve the series of mathematical equations using the initial condition values and the process parameters, to generate a value or a table of values as a function of time for one or more output functions of the biological network, thereby simulating the biological network.

40

FIG. 15

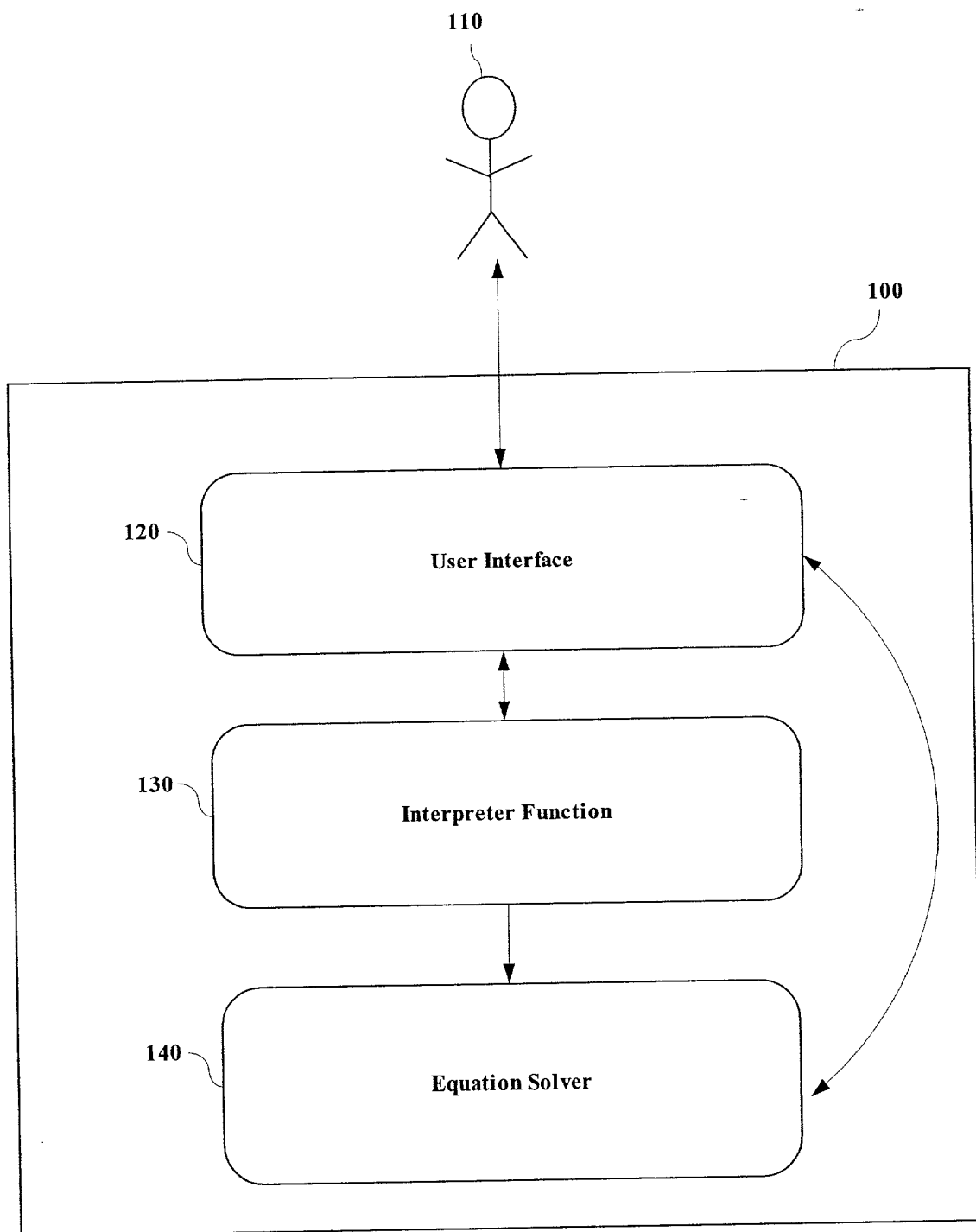


FIG. 16

Out{2}=

$$\begin{aligned} & \left\{ [K[3, 0] \stackrel{\text{RAFP}}{=} K[3, 1], a_1, d_1, k_1, a_2, d_2, k_2], \right. \\ & \left\{ [K[2, 0] \stackrel{K[3, 1]}{=} K[2, 1], a_3, d_3, k_3, a_4, d_4, k_4], \right. \\ & \left. \left. [K[2, 1] \stackrel{\text{MEKP}}{=} K[2, 2], a_5, d_5, k_5, a_6, d_6, k_6], \right. \right. \\ & \left. \left\{ [K[1, 0] \stackrel{K[2, 2]}{=} K[1, 1], a_7, d_7, k_7, a_8, d_8, k_8], \right. \right. \\ & \left. \left. [K[1, 1] \stackrel{\text{MAPKP}}{=} K[1, 2], a_9, d_9, k_9, a_{10}, d_{10}, k_{10}], \right. \right. \\ & \left. \left. [K[1, 2] \stackrel{\text{MAPKP}}{=} K[1, 3], a_{11}, d_{11}, k_{11}, a_{12}, d_{12}, k_{12}], \right. \right. \\ & \left. \left. [K[0, 0] \stackrel{K[1, 3]}{=} K[0, 1], a_{13}, d_{13}, k_{13}, a_{14}, d_{14}, k_{14}], \right. \right. \\ & \left. \left. [K[0, 1] \stackrel{\text{MEKP}}{=} K[0, 2], a_{15}, d_{15}, k_{15}, a_{16}, d_{16}, k_{16}], \right. \right. \\ & \left. \left. [K[0, 2] \stackrel{\text{MEKP}}{=} K[0, 3], a_{17}, d_{17}, k_{17}, a_{18}, d_{18}, k_{18}], \right. \right. \\ & \left. \left. [K[0, 3] \stackrel{\text{MEKP}}{=} K[0, 4], a_{19}, d_{19}, k_{19}, a_{20}, d_{20}, k_{20}], \right. \right. \\ & \left. \left. [K[0, 4] \stackrel{\text{MEKP}}{=} K[0, 5], a_{21}, d_{21}, k_{21}, a_{22}, d_{22}, k_{22}], \right. \right. \\ & \left. \left. [K[0, 5] \stackrel{\text{MEKP}}{=} K[0, 6], a_{23}, d_{23}, k_{23}, a_{24}, d_{24}, k_{24}], \right. \right. \\ & \left. \left. [K[0, 6] \stackrel{\text{MEKP}}{=} K[0, 7], a_{25}, d_{25}, k_{25}, a_{26}, d_{26}, k_{26}], \right. \right. \\ & \left. \left. [K[0, 7] \stackrel{\text{MEKP}}{=} K[0, 8], a_{27}, d_{27}, k_{27}, a_{28}, d_{28}, k_{28}], \right. \right. \\ & \left. \left. [K[0, 8] \stackrel{\text{MEKP}}{=} K[0, 9], a_{29}, d_{29}, k_{29}, a_{30}, d_{30}, k_{30}], \right. \right. \\ & \left. \left. [K[0, 9] \stackrel{\text{MEKP}}{=} K[0, 10], a_{31}, d_{31}, k_{31}, a_{32}, d_{32}, k_{32}], \right. \right. \\ & \left. \left. [K[0, 10] \stackrel{\text{MEKP}}{=} K[0, 11], a_{33}, d_{33}, k_{33}, a_{34}, d_{34}, k_{34}], \right. \right. \\ & \left. \left. [K[0, 11] \stackrel{\text{MEKP}}{=} K[0, 12], a_{35}, d_{35}, k_{35}, a_{36}, d_{36}, k_{36}], \right. \right. \\ & \left. \left. [K[0, 12] \stackrel{\text{MEKP}}{=} K[0, 13], a_{37}, d_{37}, k_{37}, a_{38}, d_{38}, k_{38}], \right. \right. \\ & \left. \left. [K[0, 13] \stackrel{\text{MEKP}}{=} K[0, 14], a_{39}, d_{39}, k_{39}, a_{40}, d_{40}, k_{40}], \right. \right. \\ & \left. \left. [K[0, 14] \stackrel{\text{MEKP}}{=} K[0, 15], a_{41}, d_{41}, k_{41}, a_{42}, d_{42}, k_{42}], \right. \right. \\ & \left. \left. [K[0, 15] \stackrel{\text{MEKP}}{=} K[0, 16], a_{43}, d_{43}, k_{43}, a_{44}, d_{44}, k_{44}], \right. \right. \\ & \left. \left. [K[0, 16] \stackrel{\text{MEKP}}{=} K[0, 17], a_{45}, d_{45}, k_{45}, a_{46}, d_{46}, k_{46}], \right. \right. \\ & \left. \left. [K[0, 17] \stackrel{\text{MEKP}}{=} K[0, 18], a_{47}, d_{47}, k_{47}, a_{48}, d_{48}, k_{48}], \right. \right. \\ & \left. \left. [K[0, 18] \stackrel{\text{MEKP}}{=} K[0, 19], a_{49}, d_{49}, k_{49}, a_{50}, d_{50}, k_{50}], \right. \right. \\ & \left. \left. [K[0, 19] \stackrel{\text{MEKP}}{=} K[0, 20], a_{51}, d_{51}, k_{51}, a_{52}, d_{52}, k_{52}], \right. \right. \\ & \left. \left. [K[0, 20] \stackrel{\text{MEKP}}{=} K[0, 21], a_{53}, d_{53}, k_{53}, a_{54}, d_{54}, k_{54}], \right. \right. \\ & \left. \left. [K[0, 21] \stackrel{\text{MEKP}}{=} K[0, 22], a_{55}, d_{55}, k_{55}, a_{56}, d_{56}, k_{56}], \right. \right. \\ & \left. \left. [K[0, 22] \stackrel{\text{MEKP}}{=} K[0, 23], a_{57}, d_{57}, k_{57}, a_{58}, d_{58}, k_{58}], \right. \right. \\ & \left. \left. [K[0, 23] \stackrel{\text{MEKP}}{=} K[0, 24], a_{59}, d_{59}, k_{59}, a_{60}, d_{60}, k_{60}], \right. \right. \\ & \left. \left. [K[0, 24] \stackrel{\text{MEKP}}{=} K[0, 25], a_{61}, d_{61}, k_{61}, a_{62}, d_{62}, k_{62}], \right. \right. \\ & \left. \left. [K[0, 25] \stackrel{\text{MEKP}}{=} K[0, 26], a_{63}, d_{63}, k_{63}, a_{64}, d_{64}, k_{64}], \right. \right. \\ & \left. \left. [K[0, 26] \stackrel{\text{MEKP}}{=} K[0, 27], a_{65}, d_{65}, k_{65}, a_{66}, d_{66}, k_{66}], \right. \right. \\ & \left. \left. [K[0, 27] \stackrel{\text{MEKP}}{=} K[0, 28], a_{67}, d_{67}, k_{67}, a_{68}, d_{68}, k_{68}], \right. \right. \\ & \left. \left. [K[0, 28] \stackrel{\text{MEKP}}{=} K[0, 29], a_{69}, d_{69}, k_{69}, a_{70}, d_{70}, k_{70}], \right. \right. \\ & \left. \left. [K[0, 29] \stackrel{\text{MEKP}}{=} K[0, 30], a_{71}, d_{71}, k_{71}, a_{72}, d_{72}, k_{72}], \right. \right. \\ & \left. \left. [K[0, 30] \stackrel{\text{MEKP}}{=} K[0, 31], a_{73}, d_{73}, k_{73}, a_{74}, d_{74}, k_{74}], \right. \right. \\ & \left. \left. [K[0, 31] \stackrel{\text{MEKP}}{=} K[0, 32], a_{75}, d_{75}, k_{75}, a_{76}, d_{76}, k_{76}], \right. \right. \\ & \left. \left. [K[0, 32] \stackrel{\text{MEKP}}{=} K[0, 33], a_{77}, d_{77}, k_{77}, a_{78}, d_{78}, k_{78}], \right. \right. \\ & \left. \left. [K[0, 33] \stackrel{\text{MEKP}}{=} K[0, 34], a_{79}, d_{79}, k_{79}, a_{80}, d_{80}, k_{80}], \right. \right. \\ & \left. \left. [K[0, 34] \stackrel{\text{MEKP}}{=} K[0, 35], a_{81}, d_{81}, k_{81}, a_{82}, d_{82}, k_{82}], \right. \right. \\ & \left. \left. [K[0, 35] \stackrel{\text{MEKP}}{=} K[0, 36], a_{83}, d_{83}, k_{83}, a_{84}, d_{84}, k_{84}], \right. \right. \\ & \left. \left. [K[0, 36] \stackrel{\text{MEKP}}{=} K[0, 37], a_{85}, d_{85}, k_{85}, a_{86}, d_{86}, k_{86}], \right. \right. \\ & \left. \left. [K[0, 37] \stackrel{\text{MEKP}}{=} K[0, 38], a_{87}, d_{87}, k_{87}, a_{88}, d_{88}, k_{88}], \right. \right. \\ & \left. \left. [K[0, 38] \stackrel{\text{MEKP}}{=} K[0, 39], a_{89}, d_{89}, k_{89}, a_{90}, d_{90}, k_{90}], \right. \right. \\ & \left. \left. [K[0, 39] \stackrel{\text{MEKP}}{=} K[0, 40], a_{91}, d_{91}, k_{91}, a_{92}, d_{92}, k_{92}], \right. \right. \\ & \left. \left. [K[0, 40] \stackrel{\text{MEKP}}{=} K[0, 41], a_{93}, d_{93}, k_{93}, a_{94}, d_{94}, k_{94}], \right. \right. \\ & \left. \left. [K[0, 41] \stackrel{\text{MEKP}}{=} K[0, 42], a_{95}, d_{95}, k_{95}, a_{96}, d_{96}, k_{96}], \right. \right. \\ & \left. \left. [K[0, 42] \stackrel{\text{MEKP}}{=} K[0, 43], a_{97}, d_{97}, k_{97}, a_{98}, d_{98}, k_{98}], \right. \right. \\ & \left. \left. [K[0, 43] \stackrel{\text{MEKP}}{=} K[0, 44], a_{99}, d_{99}, k_{99}, a_{100}, d_{100}, k_{100}], \right. \right. \\ & \left. \left. [K[0, 44] \stackrel{\text{MEKP}}{=} K[0, 45], a_{101}, d_{101}, k_{101}, a_{102}, d_{102}, k_{102}], \right. \right. \\ & \left. \left. [K[0, 45] \stackrel{\text{MEKP}}{=} K[0, 46], a_{103}, d_{103}, k_{103}, a_{104}, d_{104}, k_{104}], \right. \right. \\ & \left. \left. [K[0, 46] \stackrel{\text{MEKP}}{=} K[0, 47], a_{105}, d_{105}, k_{105}, a_{106}, d_{106}, k_{106}], \right. \right. \\ & \left. \left. [K[0, 47] \stackrel{\text{MEKP}}{=} K[0, 48], a_{107}, d_{107}, k_{107}, a_{108}, d_{108}, k_{108}], \right. \right. \\ & \left. \left. [K[0, 48] \stackrel{\text{MEKP}}{=} K[0, 49], a_{109}, d_{109}, k_{109}, a_{110}, d_{110}, k_{110}], \right. \right. \\ & \left. \left. [K[0, 49] \stackrel{\text{MEKP}}{=} K[0, 50], a_{111}, d$$

FIG. 17 (Page 1 of 4)

$\{K[1, 0] + S[-1, -1, -1] \Rightarrow S[0, -1, -1], \text{kon, koff}\},$
 $\{K[1, 0] + S[-1, -1, 0] \Rightarrow S[0, -1, 0], \text{kon, koff}\},$
 $\{K[1, 0] + S[-1, -1, 1] \Rightarrow S[0, -1, 1], \text{kon, koff}\},$
 $\{K[1, 0] + S[-1, 0, -1] \Rightarrow S[0, 0, -1], \text{kon, koff}\},$
 $\{K[1, 0] + S[-1, 0, 0] \Rightarrow S[0, 0, 0], \text{kon, koff}\},$
 $\{K[1, 0] + S[-1, 0, 1] \Rightarrow S[0, 0, 1], \text{kon, koff}\},$
 $\{K[1, 0] + S[-1, 1, -1] \Rightarrow S[0, 1, -1], \text{kon, koff}\},$
 $\{K[1, 0] + S[-1, 1, 0] \Rightarrow S[0, 1, 0], \text{kon, koff}\},$
 $\{K[1, 0] + S[-1, 1, 1] \Rightarrow S[0, 1, 1], \text{kon, koff}\},$
 $\{K[1, 0] + S[-1, 2, -1] \Rightarrow S[0, 2, -1], \text{kon, koff}\},$
 $\{K[1, 0] + S[-1, 2, 0] \Rightarrow S[0, 2, 0], \text{kon, koff}\},$
 $\{K[1, 0] + S[-1, 2, 1] \Rightarrow S[0, 2, 1], \text{kon, koff}\},$
 $\{K[1, 1] + S[-1, -1, -1] \Rightarrow S[1, -1, -1], \text{kpon, kpoff}\},$
 $\{K[1, 1] + S[-1, -1, 0] \Rightarrow S[1, -1, 0], \text{kpon, kpoff}\},$
 $\{K[1, 1] + S[-1, -1, 1] \Rightarrow S[1, -1, 1], \text{kpon, kpoff}\},$
 $\{K[1, 1] + S[-1, 0, -1] \Rightarrow S[1, 0, -1], \text{kpon, kpoff}\},$
 $\{K[1, 1] + S[-1, 0, 0] \Rightarrow S[1, 0, 0], \text{kpon, kpoff}\},$
 $\{K[1, 1] + S[-1, 0, 1] \Rightarrow S[1, 0, 1], \text{kpon, kpoff}\},$
 $\{K[1, 1] + S[-1, 1, -1] \Rightarrow S[1, 1, -1], \text{kpon, kpoff}\},$
 $\{K[1, 1] + S[-1, 1, 0] \Rightarrow S[1, 1, 0], \text{kpon, kpoff}\},$
 $\{K[1, 1] + S[-1, 1, 1] \Rightarrow S[1, 1, 1], \text{kpon, kpoff}\},$
 $\{K[1, 1] + S[-1, 2, -1] \Rightarrow S[1, 2, -1], \text{kpon, kpoff}\},$
 $\{K[1, 1] + S[-1, 2, 0] \Rightarrow S[1, 2, 0], \text{kpon, kpoff}\},$
 $\{K[1, 1] + S[-1, 2, 1] \Rightarrow S[1, 2, 1], \text{kpon, kpoff}\},$
 $\{K[1, 2] + S[-1, -1, -1] \Rightarrow S[2, -1, -1], \text{kpon, kpoff}\},$
 $\{K[1, 2] + S[-1, -1, 0] \Rightarrow S[2, -1, 0], \text{kpon, kpoff}\},$
 $\{K[1, 2] + S[-1, -1, 1] \Rightarrow S[2, -1, 1], \text{kpon, kpoff}\},$
 $\{K[1, 2] + S[-1, 0, -1] \Rightarrow S[2, 0, -1], \text{kpon, kpoff}\},$
 $\{K[1, 2] + S[-1, 0, 0] \Rightarrow S[2, 0, 0], \text{kpon, kpoff}\},$
 $\{K[1, 2] + S[-1, 0, 1] \Rightarrow S[2, 0, 1], \text{kpon, kpoff}\},$
 $\{K[1, 2] + S[-1, 1, -1] \Rightarrow S[2, 1, -1], \text{kpon, kpoff}\},$
 $\{K[1, 2] + S[-1, 1, 0] \Rightarrow S[2, 1, 0], \text{kpon, kpoff}\},$
 $\{K[1, 2] + S[-1, 1, 1] \Rightarrow S[2, 1, 1], \text{kpon, kpoff}\},$
 $\{K[1, 2] + S[-1, 2, -1] \Rightarrow S[2, 2, -1], \text{kpon, kpoff}\},$
 $\{K[1, 2] + S[-1, 2, 0] \Rightarrow S[2, 2, 0], \text{kpon, kpoff}\},$
 $\{K[1, 2] + S[-1, 2, 1] \Rightarrow S[2, 2, 1], \text{kpon, kpoff}\},$
 $\{K[2, 0] + S[-1, -1, -1] \Rightarrow S[-1, 0, -1], \text{kon, koff}\},$
 $\{K[2, 0] + S[-1, -1, 0] \Rightarrow S[-1, 0, 0], \text{kon, koff}\},$
 $\{K[2, 0] + S[-1, -1, 1] \Rightarrow S[-1, 0, 1], \text{kon, koff}\},$
 $\{K[2, 1] + S[-1, -1, -1] \Rightarrow S[-1, 1, -1], \text{kpon, kpoff}\},$
 $\{K[2, 1] + S[-1, -1, 0] \Rightarrow S[-1, 1, 0], \text{kpon, kpoff}\},$
 $\{K[2, 1] + S[-1, -1, 1] \Rightarrow S[-1, 1, 1], \text{kpon, kpoff}\},$
 $\{K[2, 2] + S[-1, -1, -1] \Rightarrow S[-1, 2, -1], \text{kpon, kpoff}\},$
 $\{K[2, 2] + S[-1, -1, 0] \Rightarrow S[-1, 2, 0], \text{kpon, kpoff}\},$
 $\{K[2, 2] + S[-1, -1, 1] \Rightarrow S[-1, 2, 1], \text{kpon, kpoff}\},$
 $\{K[2, 0] + S[0, -1, -1] \Rightarrow S[0, 0, -1], \text{kon, koff}\},$
 $\{K[2, 0] + S[0, -1, 0] \Rightarrow S[0, 0, 0], \text{kon, koff}\},$
 $\{K[2, 0] + S[0, -1, 1] \Rightarrow S[0, 0, 1], \text{kon, koff}\},$
 $\{K[2, 1] + S[0, -1, -1] \Rightarrow S[0, 1, -1], \text{kpon, kpoff}\},$
 $\{K[2, 1] + S[0, -1, 0] \Rightarrow S[0, 1, 0], \text{kpon, kpoff}\},$
 $\{K[2, 1] + S[0, -1, 1] \Rightarrow S[0, 1, 1], \text{kpon, kpoff}\},$
 $\{K[2, 2] + S[0, -1, -1] \Rightarrow S[0, 2, -1], \text{kpon, kpoff}\},$

FIG. 17 (Page 2 of 4)

$\{K[2, 2] + S[0, -1, 0] \Rightarrow S[0, 2, 0], kpon, kpo\text{ff}\},$
 $\{K[2, 2] + S[0, -1, 1] \Rightarrow S[0, 2, 1], kpon, kpo\text{ff}\},$
 $\{K[2, 0] + S[1, -1, -1] \Rightarrow S[1, 0, -1], kon, ko\text{ff}\},$
 $\{K[2, 0] + S[1, -1, 0] \Rightarrow S[1, 0, 0], kon, ko\text{ff}\},$
 $\{K[2, 0] + S[1, -1, 1] \Rightarrow S[1, 0, 1], kon, ko\text{ff}\},$
 $\{K[2, 1] + S[1, -1, -1] \Rightarrow S[1, 1, -1], kpon, kpo\text{ff}\},$
 $\{K[2, 1] + S[1, -1, 0] \Rightarrow S[1, 1, 0], kpon, kpo\text{ff}\},$
 $\{K[2, 1] + S[1, -1, 1] \Rightarrow S[1, 1, 1], kpon, kpo\text{ff}\},$
 $\{K[2, 2] + S[1, -1, -1] \Rightarrow S[1, 2, -1], kpon, kpo\text{ff}\},$
 $\{K[2, 2] + S[1, -1, 0] \Rightarrow S[1, 2, 0], kpon, kpo\text{ff}\},$
 $\{K[2, 2] + S[1, -1, 1] \Rightarrow S[1, 2, 1], kpon, kpo\text{ff}\},$
 $\{K[2, 0] + S[2, -1, -1] \Rightarrow S[2, 0, -1], kon, ko\text{ff}\},$
 $\{K[2, 0] + S[2, -1, 0] \Rightarrow S[2, 0, 0], kon, ko\text{ff}\},$
 $\{K[2, 0] + S[2, -1, 1] \Rightarrow S[2, 0, 1], kon, ko\text{ff}\},$
 $\{K[2, 1] + S[2, -1, -1] \Rightarrow S[2, 1, -1], kpon, kpo\text{ff}\},$
 $\{K[2, 1] + S[2, -1, 0] \Rightarrow S[2, 1, 0], kpon, kpo\text{ff}\},$
 $\{K[2, 1] + S[2, -1, 1] \Rightarrow S[2, 1, 1], kpon, kpo\text{ff}\},$
 $\{K[2, 2] + S[2, -1, -1] \Rightarrow S[2, 2, -1], kpon, kpo\text{ff}\},$
 $\{K[2, 2] + S[2, -1, 0] \Rightarrow S[2, 2, 0], kpon, kpo\text{ff}\},$
 $\{K[2, 2] + S[2, -1, 1] \Rightarrow S[2, 2, 1], kpon, kpo\text{ff}\},$
 $\{K[3, 0] + S[-1, -1, -1] \Rightarrow S[-1, -1, 0], kon, ko\text{ff}\},$
 $\{K[3, 1] + S[-1, -1, -1] \Rightarrow S[-1, -1, 1], kpon, kpo\text{ff}\},$
 $\{K[3, 0] + S[-1, 0, -1] \Rightarrow S[-1, 0, 0], kon, ko\text{ff}\},$
 $\{K[3, 1] + S[-1, 0, -1] \Rightarrow S[-1, 0, 1], kpon, kpo\text{ff}\},$
 $\{K[3, 0] + S[-1, 1, -1] \Rightarrow S[-1, 1, 0], kon, ko\text{ff}\},$
 $\{K[3, 1] + S[-1, 1, -1] \Rightarrow S[-1, 1, 1], kpon, kpo\text{ff}\},$
 $\{K[3, 0] + S[-1, 2, -1] \Rightarrow S[-1, 2, 0], kon, ko\text{ff}\},$
 $\{K[3, 1] + S[-1, 2, -1] \Rightarrow S[-1, 2, 1], kpon, kpo\text{ff}\},$
 $\{K[3, 0] + S[0, -1, -1] \Rightarrow S[0, -1, 0], kon, ko\text{ff}\},$
 $\{K[3, 1] + S[0, -1, -1] \Rightarrow S[0, -1, 1], kpon, kpo\text{ff}\},$
 $\{K[3, 0] + S[0, 0, -1] \Rightarrow S[0, 0, 0], kon, ko\text{ff}\},$
 $\{K[3, 1] + S[0, 0, -1] \Rightarrow S[0, 0, 1], kpon, kpo\text{ff}\},$
 $\{K[3, 0] + S[0, 1, -1] \Rightarrow S[0, 1, 0], kon, ko\text{ff}\},$
 $\{K[3, 1] + S[0, 1, -1] \Rightarrow S[0, 1, 1], kpon, kpo\text{ff}\},$
 $\{K[3, 0] + S[0, 2, -1] \Rightarrow S[0, 2, 0], kon, ko\text{ff}\},$
 $\{K[3, 1] + S[0, 2, -1] \Rightarrow S[0, 2, 1], kpon, kpo\text{ff}\},$
 $\{K[3, 0] + S[1, -1, -1] \Rightarrow S[1, -1, 0], kon, ko\text{ff}\},$
 $\{K[3, 1] + S[1, -1, -1] \Rightarrow S[1, -1, 1], kpon, kpo\text{ff}\},$
 $\{K[3, 0] + S[1, 0, -1] \Rightarrow S[1, 0, 0], kon, ko\text{ff}\},$
 $\{K[3, 1] + S[1, 0, -1] \Rightarrow S[1, 0, 1], kpon, kpo\text{ff}\},$
 $\{K[3, 0] + S[1, 1, -1] \Rightarrow S[1, 1, 0], kon, ko\text{ff}\},$
 $\{K[3, 1] + S[1, 1, -1] \Rightarrow S[1, 1, 1], kpon, kpo\text{ff}\},$
 $\{K[3, 0] + S[1, 2, -1] \Rightarrow S[1, 2, 0], kon, ko\text{ff}\},$
 $\{K[3, 1] + S[1, 2, -1] \Rightarrow S[1, 2, 1], kpon, kpo\text{ff}\},$
 $\{K[3, 0] + S[2, -1, -1] \Rightarrow S[2, -1, 0], kon, ko\text{ff}\},$
 $\{K[3, 1] + S[2, -1, -1] \Rightarrow S[2, -1, 1], kpon, kpo\text{ff}\},$
 $\{K[3, 0] + S[2, 0, -1] \Rightarrow S[2, 0, 0], kon, ko\text{ff}\},$
 $\{K[3, 1] + S[2, 0, -1] \Rightarrow S[2, 0, 1], kpon, kpo\text{ff}\},$
 $\{K[3, 0] + S[2, 1, -1] \Rightarrow S[2, 1, 0], kon, ko\text{ff}\},$
 $\{K[3, 1] + S[2, 1, -1] \Rightarrow S[2, 1, 1], kpon, kpo\text{ff}\},$
 $\{K[3, 0] + S[2, 2, -1] \Rightarrow S[2, 2, 0], kon, ko\text{ff}\},$
 $\{K[3, 1] + S[2, 2, -1] \Rightarrow S[2, 2, 1], kpon, kpo\text{ff}\},$

FIG. 17 (Page 3 of 4)

$$Out[3]=$$

```

[MAPKP'[t] == -a8 MAPKP[t] K[1, 1][t] -
  a10 MAPKP[t] K[1, 2][t] + d8 K#MAPKP[1, 1][t] + k8 K#MAPKP[1, 1][t] +
  d10 K#MAPKP[1, 2][t] + k10 K#MAPKP[1, 2][t], MEKP'[t] ==
  -a4 MEKP[t] K[2, 1][t] - a6 MEKP[t] K[2, 2][t] + d4 K#MEKP[2, 1][t] +
  k4 K#MEKP[2, 1][t] + d6 K#MEKP[2, 2][t] + k6 K#MEKP[2, 2][t],
  RAFK'[t] == -a1 RAFK[t] K[3, 0][t] + d1 K#RAFK[3, 0][t] +
  k1 K#RAFK[3, 0][t] - k1a RAFK[t] S[-1, -1, 0][t] -

```

FIG. 18 (Page 1 of 10)